

WHAT IS CLAIMED IS:

1 1. A cryotherapy system comprising:
2 a plurality of cryoprobes, each such cryoprobe having a shaft with a closed
3 distal end adapted for insertion into a body and conduits for flowing a cryogenic fluid
4 through the shaft to reduce a temperature of the distal end;
5 a source of the cryogenic fluid;
6 a plurality of flow-control metering valves in fluid communication with the
7 conduits of the plurality of cryoprobes and with the source of the cryogenic fluid;
8 a compressor in fluid communication with the conduits of the plurality of
9 cryoprobes to define a self-contained fluid system; and
10 a computer processor adapted to control the plurality of flow-control metering
11 valves and the compressor to provide desired flows of the cryogenic fluid through the
12 conduits of the self-contained fluid system.

1 2. The cryotherapy system recited in claim 1 wherein the self-contained
2 fluid system is an open-loop system.

1 3. The cryotherapy system recited in claim 1 wherein the self-contained
2 fluid system is a closed-loop system.

1 4. The cryotherapy system recited in claim 1 wherein:
2 the cryogenic fluid is a gas; and
3 each such cryoprobe further has a heat exchanger disposed within the shaft in
4 thermal communication with the conduits of such cryoprobe.

1 5. The cryotherapy system recited in claim 4 wherein:
2 each of the plurality of cryoprobes includes a Joule-Thomson port disposed in
3 the distal end of the shaft in thermal communication with the heat exchanger; and
4 the computer processor is further adapted to control operation of each of the
5 Joule-Thomson ports.

1 6. The cryotherapy system recited in claim 1 wherein:
2 the cryogenic fluid is a liquid; and
3 the computer processor is adapted to control the compressor and plurality of
4 flow-control metering valves to provide an initial flow of the liquid through the conduits of

the cryoprobes under physical conditions near a critical point of a liquid-vapor system for the liquid,

whereby vapor lock associated with freezing of the cryoprobes is avoided.

7. The cryotherapy system recited in claim 6 wherein the computer processor is further adapted subsequently to reduce a pressure of the liquid in the cryoprobes, whereby colder liquid temperatures may be maintained without vapor lock after the initial flow is established.

8. The cryotherapy system recited in claim 6 wherein the compressor comprises a submersible pump for compressing ambient cryogenic liquids.

9. The cryotherapy system recited in claim 8 wherein the compressor comprises a heat exchanger to remove heat of compression through heat exchange of the compressed cryogenic liquid with the ambient cryogenic liquids.

10. The cryotherapy system recited in claim 8 wherein:
the plurality of cryoprobes are in fluid communication with the submersible pump through respective supply lines; and
the computer processor is further adapted to set a freeze power of the plurality of cryoprobes by regulating flow through the respective supply lines.

11. The cryotherapy system recited in claim 6 wherein the compressor comprises a push-pull bellow system and a linear actuator motor.

12. The cryotherapy system recited in claim 11 wherein the computer processor is further adapted to control a force exerted by the linear actuator motor to set a pressure of the cryogenic liquid.

13. The cryotherapy system recited in claim 6 further comprising a source of warmed gas in fluid communication with the flow-control metering valves, wherein the computer processor is further adapted to control the flow-control metering valves to initiate flow of the warmed gas through the conduits as part of an active thaw procedure.

14. The cryotherapy system recited in claim 1 wherein the computer processor is further adapted to determine the desired flows from predefined imaging parameters.

1 15. The cryotherapy system recited in claim 1 wherein the predefined
2 imaging parameters correspond to a definition of freeze margins in the body.

1 16. The cryotherapy system recited in claim 1 wherein:
2 each of the plurality of cryoprobes further has a plurality of multifunction
3 electrical wires; and
4 the computer processor is adapted to monitor the operation of the
5 multifunction electrical wires.

1 17. The cryotherapy system recited in claim 16 wherein the computer
2 processor is adapted to monitor operation of the multifunction electrical wires to monitor a
3 temperature.

1 18. The cryotherapy system recited in claim 16 wherein the computer
2 processor is adapted to monitor operation of the multifunction electrical wires to provide
3 heat.

1 19. The cryotherapy system recited in claim 16 wherein:
2 the body is a living body; and
3 the computer processor is adapted to monitor the operation of the
4 multifunction electrical wires to stimulate a nerve within the living body.

1 20. The cryotherapy system recited in claim 16 wherein the computer
2 processor is adapted to monitor the operation of the multifunction electrical wires to permit
3 spatial localization of the cryoprobes.

1 21. The cryotherapy system recited in claim 1 wherein:
2 the ends of the cryoprobes comprise an electrically insulating material; and
3 the computer processor is further adapted to force current between the ends of
4 the cryoprobes to heat intervening portions of the body.

1 22. The cryotherapy system recited in claim 1 wherein the computer
2 processor is further adapted to initiate injection of a cryosensitizing substance into the body.

1 23. A computer-readable storage medium having a computer-readable
2 program embodied therein for directing operation of a cryotherapy system including a

plurality of cryoprobes, each such cryoprobe having a shaft with a closed distal end adapted for insertion into a body and conduits for flowing a cryogenic fluid through the shaft to reduce a temperature of the distal end, a source of the cryogenic fluid, a plurality of flow-control metering valves in fluid communication with the conduits of the plurality of cryoprobes and with the source of the cryogenic fluid, a compressor in fluid communication with the conduits of the plurality of cryoprobes to define a self-contained fluid system, and a computer processor, wherein the computer-readable program includes:

instructions for controlling the plurality of flow-control metering valves and the compressor to provide desired flows of the cryogenic fluid through the conduits of the self-contained fluid system.

24. The computer-readable storage medium recited in claim 23 wherein the self-contained fluid system is an open-loop system.

25. The computer-readable storage medium recited in claim 23 wherein the self-contained fluid system is a closed-loop system.

26. The computer-readable medium recited in claim 23 wherein:
the cryogenic fluid is a gas;
each such cryoprobe further has a heat exchanger disposed within the shaft in thermal communication with the conduits of such cryoprobe and has a Joule-Thomson port disposed in the distal end of the shaft in thermal communication with the heat exchanger; and
the computer-readable program further has instructions for controlling operation of each of the Joule-Thomson ports.

27. The computer-readable storage medium recited in claim 23 wherein:
the cryogenic fluid is a liquid; and
the computer-readable program further has instructions for controlling the compressor and plurality of flow-control metering valves to provide an initial flow of the liquid through the conduits of the cryoprobes under physical conditions near a critical point of a liquid-vapor system for the liquid,
whereby vapor lock associated with freezing of the cryoprobes is avoided.

28. The computer-readable storage medium recited in claim 27 wherein the computer-readable program further has instructions for controlling the compressor and plurality of flow-control metering valves to reduce a pressure of the liquid in the cryoprobes,

whereby colder liquid temperatures may be maintained without vapor lock after the initial flow is established.

29. The computer-readable storage medium recited in claim 23 wherein the computer-readable program further has instructions for determining the desired flows from predefined imaging parameters..

30. The computer-readable storage medium recited in claim 23 wherein:
each of the plurality of cryoprobes further has a plurality of multifunction electrical wires; and
the computer-readable program further has instructions for monitoring the operation of the multifunction electrical wires.

31. A system for determining a temperature within a body, the system comprising:
a current source;
a voltage-measurement device;
a wire within the body and in electrical communication with the current source and voltage-measurement device; and
a controller in electrical communication with the current source and voltage-measurement device, and adapted to:
supply a measurement current to the wire with the current source;
measure a forward voltage with the voltage-measurement device while holding the measurement current substantially constant;
reverse a direction of the current by applying a negative of the measured forward voltage to the wire with the current source;
measure a reverse voltage with the voltage-measurement device while the direction of the current is reversed;
determine a resistance of the wire from the measured voltages to account for a thermal electromotive force differential associated with measurement leads in electrical communication with the wire; and
determine the temperature from the determined resistance and a calibrated variation of resistance with temperature.

1 32 . The system recited in claim 31 wherein the wire is comprised by a
2 cryotherapy probe having a shaft with a closed distal end adapted for insertion into the body,
3 conduits for flowing cryogenic fluid within the shaft, and a post disposed within the closed
4 distal end, the wire forming a plurality of turns about the post.

1 33. The system recited in claim 31 wherein the wire is comprised by a
2 probe containing at least one temperature measuring point.